OPTICS I : Homwork #3

(Due: 2 weeks)

[4.9] Calculate the transmission angle for a ray incident in air at 30° on a black of crown glass (n_g=1.52).

[4.14] A beam of 12-cm planar microwaves strikes the surface of a dielectric at 45°. If n_{ti}=4/3, compute (a) the wavelength in the transmitting medium, and (b) the angle θ_t.

[4.18] Make a plot of θ_i versus θ_t for an air-glass boundary where n_{glass}=1.5. Discuss the shape of the curve.

[4.38] Suppose a lightwave that is linearly polarized in the plane of incidence impinges at 30° on a crown-glass (n_g=1.52) plate in air. Compute the appropriate amplitude reflection and transmission coefficients at the interface. Compare your results with Fig. 4.39

[4.39] Derive Eqs. (4.42) through (4.45) for reflection and transmission coefficients of each polarization.

[4.22] Imagine that you are standing in the path of an antenna that is radiating plane waves of frequency 100 MHz and flux density 19.88 x 10^{-2} W/m^2. Compute the photon flux density, that is, the number of photons per unit time per unit area. How many photons, on the average, will be found in a cubic meter of this region?

[4.38] Suppose a lightwave that is linearly polarized in the plane-of-incidence impinges at 30° on a crown-glass (n_g=1.52) plate in air. Compute the appropriate reflection and transmission coefficients at the interface.

[4.39] Derive Fresnel equations (Eqs. (4.42) through (4.45)) for $r_\perp$, $r_\parallel$, $t_\perp$, $t_\parallel$.

[4.50] Prove that

$$r_\perp + (-r_\perp) = 1 \quad (4.49)$$

for all incident angles, first from the boundary conditions and then from the Fresnel equations.

[4.59] Derive an expression for the speed of the evanescent wave in the case of internal reflection. Write it in terms of c, n_i, and θ_i.

[4.60] Light having a vacuum wavelength of 600 nm, traveling in a glass (n_g=1.50) block, is incident at 45° on a glass-air interface. It is then totally internally reflected. Determine the distance into the air at which the amplitude of the evanescent wave has dropped to a value of 1/*e* of its maximum value at the interface.

[4.62] Consider the common mirage associated with an inhomogeneous distribution of air situated above a warm roadway. Envision the bending of the rays as if it were instead a problem in total internal reflection. If an observer, at whose head n_a=1.00029, sees an apparent wet spot at $\theta_i \geq 88.7°$ down the road, find the index of the air immediately above the road.

[4.64] Show that $\tan\theta_p = n_t/n_i$ and calculate the polarization angle for external incidence on a plate of crown glass (n_g=1.52) in air.

[4.69] Make a sketch of $R_\perp$ and $R_\parallel$ for n_i=1.5 and n_t=1 (internal reflection).

[4.74] Show that at normal incidence on the boundary between two dielectrics, as $n_{ti}\to 1$, $R\to 0$, and $T\to 1$. Moreover, prove that as $n_{ti}\to 1$, $R_\parallel \to 0$, $R_\perp\to 0$, $T_\parallel \to 1$and $T_\perp\to 1$ for all incident angles. Thus as the two media take on more similar indices of refraction, less and less energy is carried off in the reflected wave. It should be obvious that when n_{ti}=1 there will be no interface and no reflection.

[4.82] The function of a prism-coupler arrangement is to feed a laser beam into a thin (0.000 01 inch) transparent film, which then serves as a sort of waveguide. One application is that of thin-film laser beam circuitry – a kind of integrated optics. How do you think it works?